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FORM PTO-1390 US DEPARTMENT OF COMMERCE REV. 5-93PATENT AND TRADEMARK OFFICE **TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371**	ATTORNEYS DOCKET NUMBER **P01,0281** U.S. APPLICATION NO. (if known, see 37 CFR 1.5) **09/914899**

INTERNATIONAL APPLICATION NO. **PCT/DE00/00630**	INTERNATIONAL FILING DATE **01 MARCH 2000**	PRIORITY DATE CLAIMED **01 MARCH 1999**

TITLE OF INVENTION

METHOD AND ARRANGEMENT FOR OPTIMIZING AN AMPLITUDE-MODULATED OPTICAL SIGNAL

APPLICANT(S) FOR DO/EO/US

ULLRICH WÜNSCHE ET AL.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ⊠ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. □ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ⊠ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay.
4. ⊠ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ⊠ A copy of International Application as filed (35 U.S.C. 371(c)(2)).
   a. ⊠ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. □ has been transmitted by the International Bureau.
   c. □ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ⊠ A translation of the International Application into English (35 U.S.C. 371(c)(2).
7. ⊠ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. §371(c)(3))
   a. □ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. □ have been transmitted by the International Bureau.
   c. □ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ⊠ have not been made and will not be made.
8. □ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ⊠ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ⊠ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. □ An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98; **(PTO 1449, Prior Art, Search Report, 03 References).**
12. ⊠ An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included. **(SEE ATTACHED ENVELOPE)**
13. ⊠ Amendment "A" Prior to Action and Appendix "A".
    □ A SECOND or SUBSEQUENT preliminary amendment.
14. ⊠ A substitute specification and substitute specification mark-up.
15. ⊠ A change of address letter attached to the Declaration.
16. ⊠ Other items or information:
    a. ⊠ SUBMISSION OF DRAWING CHANGES
    b. ⊠ Copy of INTERNATIONAL SEARCH REPORT
    b. ⊠ EXPRESS MAIL #EJ 552525974 US dated September 4, 2001

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U.S. APPLICATION NO. (if known, see 37 C.F.R. 1.5) 09/914899	INTERNATIONAL APPLICATION NO PCT/DE00/00630	ATTORNEY'S DOCKET NUMBER P01,0281

17. ☒ The following fees are submitted:

				CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5): Search Report has been prepared by the EPO or JPO $860.00 International preliminary examination fee paid to USPTO (37 C F.R. 1.482) $690.00 No international preliminary examination fee paid to USPTO (37 C.F.R 1.482) but international search fee paid to USPTO (37 C.F.R. 1.445(a)(2) $710.00 Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search fee (37 C.F.R. 1.445(a)(2) paid to USPTO $1000.00 International preliminary examination fee paid to USPTO (37 C.F.R 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $ 100.00					
ENTER APPROPRIATE BASIC FEE AMOUNT =				$ 860.00	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 C F.R. 1.492(e))				$	
Claims	Number Filed	Number Extra	Rate		
Total Claims	07 - 20 =	0	X $ 18.00	$	
Independent Claims	02 - 3 =	0	X $ 80.00	$	
Multiple Dependent Claims			$270.00 +	$	
TOTAL OF ABOVE CALCULATIONS =				$ 860.00	
Reduction by ½ for filing by small entity, if applicable. Verified Small Entity statement must also be filed (Note 37 C.F.R. 1.9, 1.27, 1.28)				$	
SUBTOTAL =				$ 860.00	
Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$ 860.00	
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). $40.00 per property +					
TOTAL FEES ENCLOSED =				$ 860.00	
				Amount to be refunded	$
				charged	$

a. ☒ A check in the amount of $ 860.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. __________ in the amount of $ _______ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **50-1519**. **A duplicate copy of this sheet is enclosed.**

NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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BOX PCT
IN THE UNITED STATES DESIGNATED/ELECTED OFFICE
OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER THE PATENT COOPERATION TREATY--CHAPTER II

PRELIMINARY AMENDMENT A
PRIOR TO ACTION

APPLICANT(S): Ullrich WÜNSCHE et al.
ATTORNEY DOCKET NO.: P01,0281
INTERNATIONAL APPLICATION NO: PCT/DE00/00630
INTERNATIONAL FILING DATE: 01 March 2000
INVENTION: Method and Arrangement for Optimizing an Amplitude-Modulated Optical Signal

Assistant Commissioner for Patents,
Washington D.C. 20231

Sir:

Applicants herewith amend the above-referenced PCT application, and request entry of the Amendment prior to examination on the United States Examination Phase.

IN THE CLAIMS:

On amended page 6:

replace line 1 with --WHAT IS CLAIMED IS:--;

Please replace original claims 1-7 with the following rewritten claims 1-7, referring to the mark-ups in Appendix A.

1. (Amended) A method for optimizing an amplitude-modulated optical signal, comprising the steps of:

generating said amplitude-modulated optical signal in a modulator by modulating an optical signal with a digital signal;

feeding said amplitude-modulated optical signal to a frequency discriminator which outputs a spectral distribution signal;

feeding said spectral distribution signal to a control device which is also fed an adjustable reference signal; and

generating a control signal which sets an operating point of said modulator by comparing said adjustable reference signal and said spectral distribution signal.

2. (Amended) The method as claimed in claim 1, further comprising the step of separating a measuring signal which is fed to said frequency discriminator from said amplitude-modulated optical signal.

3. (Amended) The method as claimed in claim 1, further comprising the steps of:

determining said spectral distribution signal at a start of a transmission path; and

setting said reference signal based on properties of said transmission path.

4. (Amended) The method as claimed in claim 1, further comprising the steps of:

determining said spectral distribution signal at a receiving end; and

transmitting said spectral distribution signal or a control signal generated therefrom to said modulator provided at a transmitting end.

5. (Amended) The method as claimed in claim 1, wherein said control signal is obtained during periodically occurring time windows.

6. (Amended) An arrangement for optimizing an amplitude-modulated optical signal, comprising:

a light source;

a modulator having an output, said modulator being fed an optical signal from said light source and a digital signal for amplitude modulation;

a frequency discriminator which outputs a spectral distribution signal that is connected to said output of said modulator via a splitter; and

a control device with a reference signal setting device which is fed said spectral distribution signal and which generates a control signal which controls an operating point of said modulator.

7. (Amended) The arrangement as claimed in claim 6, further comprising an adder which is fed said control signal and said digital signal, an adder output being fed to a modulation input of said modulator.

REMARKS

The present Amendment revises the specification and claims to conform to United States patent practice, before examination of the present PCT application in the United States National Examination Phase. Pursuant to 37 CFR 1.125 (b), applicants have concurrently submitted a substitute specification, excluding the claims, and provided a marked-up copy. All of the changes are editorial and applicant believes no new matter is added thereby. The amendment, addition, and/or cancellation of claims is not intended to be a surrender of any of the subject matter of those claims.

Early examination on the merits is respectfully requested.

Submitted by,

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Appendix A
Mark-Ups for Claim Amendments

1. **(Amended)** A method for optimizing an amplitude-modulated optical signal[~~ (OSM)~~], [~~which is generated~~]**comprising the steps of:**

generating said amplitude-modulated optical signal in a modulator[~~ (2)~~] by modulating an optical signal [~~(OS) ~~]with [~~the aid of~~]a digital signal[~~ (DS),~~]**;**

[~~——characterized~~]

[~~ in that the~~]**feeding said** amplitude-modulated optical signal [~~(OSM) is fed~~]to a frequency discriminator[~~ (5)~~] which outputs a[~~ spectral distribution signal~~][~~(SV),~~] **spectral distribution signal;**

[~~——in that the~~][~~ spectral distribution signal~~][~~(SV) is fed~~]**feeding said spectral distribution signal** to a control device [~~(6)~~]which is also fed [~~a~~]**an** adjustable reference signal[~~ (RS),~~]**;** and

[~~ in that the~~]**generating a** control signal[~~ (SR ——)~~] which sets [~~the~~]**an** operating point of [~~the~~]**said** modulator[~~ (2) is generated~~] by comparing [~~the two signals~~]**said adjustable reference signal and said spectral distribution signal**.

[~~2. ——~~][~~The method as claimed in claim 1,~~]

[~~——characterized~~]

2. [~~in that~~]**(Amended) The method as claimed in claim 1, further comprising the step of separating** a measuring signal [~~(OMT)~~]which is fed to [~~the~~]**said** frequency discriminator[~~ (5) is separated~~] from [~~the~~]**said** amplitude-modulated optical signal[~~ (OSM)~~].

3. **(Amended)** The method as claimed in claim [~~1 or 2,~~]**1, further comprising the steps of:**

[~~——characterized~~]

[~~in that the~~]**determining said** spectral distribution signal [~~(SV) is determined~~]at [~~the~~]**a** start of a transmission path[~~,~~]**;** and [~~in that the~~]

setting said reference signal [~~(RS) is set taking account of the~~]**based on** properties of [~~the~~]**said** transmission path[~~ (3)~~].

4. **(Amended)** The method as claimed in claim [~~1 or 2,~~]**1, further comprising the steps of:**

[~~——characterized~~]

[~~in that the spectral distribution signal (SV) is determined at the~~]**determining said spectral distribution signal** ~~(SV),~~**at a** receiving end[~~,~~]**;** and

[~~in that the spectral distribution signal (SV)~~]**transmitting said** ~~in that the~~ **spectral distribution signal** or a control signal[~~ (SR)~~] generated therefrom [~~is transmitted~~]to [~~the~~]**said** modulator [~~(2)~~]provided at [~~the~~]**a** transmitting end.

[~~5. The method as claimed in one of the preceding claims,~~]

[~~characterized~~]

5. [~~in that the~~]**(Amended)** ~~2.~~ **The method as claimed in claim 1, wherein said** control signal[~~ (SR)~~] is obtained during periodically occurring time windows[~~ (ZF)~~].

6. **(Amended)** An arrangement for optimizing an amplitude-modulated optical signal[~~ (OSM)~~], [~~having~~]**comprising:**

a light source[~~ (1) and~~]**;**

a **modulator having an output, said** modulator [~~(2) to which there are~~]**being** fed an optical signal [~~(OS)~~]from [~~the~~]**said** light source[~~ (1)~~] and a digital signal [~~(DS)~~]for amplitude modulation[~~,~~]**;**

[~~characterized~~]

[~~ in that the~~]**a** frequency discriminator[~~ (5)~~] which outputs a spectral distribution signal [~~(SV)~~]**that** is [~~corrected~~]**connected** to [~~the~~]**said** output of [~~the~~]**said** modulator[~~ (2)~~] via a splitter**;** [~~(4),~~]and[~~ in that~~]

a control device[~~ (6) is provided~~] with a reference signal setting device [~~(7)~~]which is fed [~~the~~]**said** spectral distribution signal[~~ (SV)~~] and which generates a control signal [~~(SR)~~]which controls [~~the~~]**an** operating point of [~~the~~]**said** modulator[~~ (2)~~].

7. **(Amended)** The arrangement as claimed in claim 6,

[~~characterized~~][~~ in that~~] **further comprising** an adder[~~ is provided~~] which is fed [~~the~~]**said** control signal [~~(SR)~~]and [~~the~~]**said** digital signal[~~ (DS)~~], [~~and~~][~~ in that the~~]**an** adder output [~~is~~]**being** fed to a modulation input of [~~the~~]**said** modulator[~~ (2)~~].

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Description

Method and arrangement for optimizing of an amplitude-modulated optical signal

The invention relates to methods according to the preamble of patent claim 1, and to an arrangement according to the preamble of claim 6.

Digital signals are frequently transmitted in optical networks with the aid of amplitude modulation (ASK). A carrier wave is transmitted in the case of one logic state, and no signal is transmitted during the other logic state. As early as the modulation (on-off), what is termed a chirp is produced in which the wavelength of the output signal, and also the amplitude thereof, are changed. The transient component of the chirp causes large variations in the region of the edges, a sharp increase or decrease, [sic] in the wavelength, the switch-on edge being of particular importance, since the changes occur in the case of a full signal level. The other, adiabatic component of the chirp can be kept small by a suitable design of the modulator.

During transmission of the pulse in a waveguide (glass fiber), self-phase modulation of the carrier occurs, this being a further form of the chirp, in which the wavelength changes likewise particularly in the leading edge region and trailing edge region of the pulse. Amplitude distortions can occur, in addition.

The two wavelength distortions, the transient component of the chirp induced by switching on, and the self-phase modulation result in pulse distortion of the baseband signal which, particularly in the case of transmission systems with high bit rates, contribute to limiting the data rate and the transmission range.

An attempt is usually made to minimize the chirp-induced disturbing influences by setting operating points of Mach-Zehnder modulators or integrated electro-absorption modulators in the test bay. However, resettings must be undertaken when changes occur to the operating parameters.

GB 2 308 675 A discloses an arrangement and a method for driving an optical modulator. The printed publication describes the setting of a chirp parameter. Monitoring the modulated signal is performed at the receiving end, in order to set the chirp parameters via a back channel for pulse compression.

GB 2 316 821 A describes an optical time-division multiplex system which compensates the chromatic dispersion of the transmission path by means of controlled chirping of the transmitted signal. Monitoring of the modulated signal is not provided.

From [sic] the earlier application EP 0 971 493 A1 likewise describes a method for compensating dispersion and nonlinearities in optical communication systems. In this system, however, it is, for example, the error rate which is measured and the transmission level which

is controlled as parameters. Both measures do not appear to be expedient in modern optical systems.

It is therefore the object of the invention to specify a method and an arrangements [sic] for permanent optimization of the pulse shape/spectral distribution of an amplitude-modulated optical signal, particularly taking account of the modulation-induced chirp and the self-phase modulation in optical transmission systems.

Achievements of this object are specified in the independent claims. Advantageous developments of the invention are specified in the subclaims.

The measures according to the invention consist in using quality criteria for optimal modulation of the optical signal to set the operating point of the modulator and to maintain the optimum setting by means of a control loop.

An advantageous and simple solution is to derive a measuring signal from the modulated optical digital signal and feed it to a frequency discriminator. The output signal of the latter is - [sic] led via a control device - [sic] which determines the operating point of the modulator.

If the measuring signal is tapped at the receiving end, the properties of the transmission path can be taken into account by means of an adjustable reference signal. The output signal of the modulator is set so as to produce an optimal received signal.

If a back channel, as a rule a service channel, is available, a measuring signal can be tapped from the baseband signal and evaluated. The spectral distribution signal output by a phase discriminator, or a control signal generated therefrom will be transmitted to the source of the signal, the modulator.

The invention is explained in more detail with the aid of an exemplary embodiment.

In the drawing:

Figure 1 shows a first exemplary embodiment with spectral appraisal.

Figure 1 shows a first exemplary embodiment of a control loop for optimizing the modulation-induced chirp. The block diagram shows only modules essential to the invention. A laser provided as a narrow-band light source 1 supplies an optical signal OS of high frequency, which is fed to a modulator 2. The latter is submitted to amplitude modulation by means of a digital signal DS (on-off keying). The modulated optical signal OSM, output by the modulator, is fed into an optical conductor of a transmission path 3 and transmitted. A measuring signal OMT of low power is tapped from the modulated signal via a splitter (coupler) 4 and fed to a frequency discriminator 5. The latter can include, for example, an optical filter whose edge, which is as rectilinear as possible, is used for frequency

demodulation. The demodulated optical signal is converted into an electric spectral distribution signal SV and fed to a control device 6. The latter is fed as reference input an adjustable reference signal RS which is generated via a reference setting device 7, a voltage divider in the example. The control device supplies as manipulated variable a control signal SR which sets the operating point of the modulator and thereby optimizes the transient chirp of the modulated optical signal even in the case of changes in the component properties.

An optimum setting is given when the receive signal is optimal. A measurement at the receiving end is actually required for this purpose. However, a compact replacement transmission path used for the setting likewise permits an exact setting. The spectral distribution signal serves as criterion during setting. A specific envelope of the modulated signal corresponds to this criterion, and can likewise serve as criterion.

If the properties of the transmission path are known, they are already taken into account during setting, and the spectral distribution (or a pulse shape) is set so as to produce optimal receiving conditions.

Since the spectral distribution signal SV can be weakly dependent on the on the [sic] bit sequence of the digital signal, it can be expedient to have a time window ZF during which specific bit sequences are transmitted and the control signal is determined.

It remains to add that the control signal RS and the digital signal can be combined by an adder, and the aggregate signal is then fed to the modulation input of the modulator.

As in the arrangement illustrated in figure 1, it is also possible, of course, to appraise the spectral distribution of a modulated optical signal at the receiving end, and a corresponding spectral distribution signal or else the control signal derived therefrom is transmitted [sic] to the transmitting part.

List of reference symbols

DS	Digital signal
DD	Demodulated digital signal
1	Laser
2	Modulator
3	Optical conductor
4	Splitter
5	Discriminator
6	Control device
7	Reference setting device
RS	Reference signal
OS	Optical signal
OSM	Amplitude-modulated optical signal
OMT	Measuring signal
SV	Spectral distribution signal
SF	Control signal
ZF	Time window
8	Summing device
9	Receiving device
10	Optoelectric transducer
11	Amplifier
12	Decision circuit
13	Data output
14	Measuring instrument appraising device
15	Evaluation device
16	Controller
17	Modulation input
18	Transmitting device
19	Receiving device
SE	Setting signal

Patent claims

1. A method for optimizing an amplitude-modulated optical signal (OSM), which is generated in a modulator (2) by modulating an optical signal (OS) with the aid of a digital signal (DS),

characterized

in that the amplitude-modulated optical signal (OSM) is fed to a frequency discriminator (5) which outputs a spectral distribution signal (SV),

in that the spectral distribution signal (SV) is fed to a control device (6) which is also fed a adjustable reference signal (RS), and

in that the control signal (SR) which sets the operating point of the modulator (2) is generated by comparing the two signals.

2. The method as claimed in claim 1,

characterized

in that a measuring signal (OMT) which is fed to the frequency discriminator (5) is separated from the amplitude-modulated optical signal (OSM).

3. The method as claimed in claim 1 or 2,

characterized

in that the spectral distribution signal (SV) is determined at the start of a transmission path, and in that the reference signal (RS) is set taking account of the properties of the transmission path (3).

4. The method as claimed in claim 1 or 2,

characterized

in that the spectral distribution signal (SV) is determined at the receiving end, and

in that the spectral distribution signal (SV) or a control signal (SR) generated therefrom is transmitted to the modulator (2) provided at the transmitting end.

5. The method as claimed in one of the preceding claims,

characterized

in that the control signal (SR) is obtained during periodically occurring time windows (ZF).

6. An arrangement for optimizing an amplitude-modulated optical signal (OSM), having a light source (1) and a modulator (2) to which there are fed an optical signal (OS) from the light source (1) and a digital signal (DS) for amplitude modulation,

characterized

in that the frequency discriminator (5) which outputs a spectral distribution signal (SV) is corrected to the output of the modulator (2) via a splitter (4),

and in that a control device (6) is provided with a reference signal setting device (7) which is fed the spectral distribution signal (SV) and which generates a control signal (SR) which controls the operating point of the modulator (2).

7. The arrangement as claimed in claim 6,

characterized

in that an adder is provided which is fed the control signal (SR) and the digital signal (DS), and

in that the adder output is fed to a modulation input of the modulator (2).

[~~Abstract~~]

[~~Method and arrangement for optimizing the pulse shape of an amplitude modulated optical signal~~]**ABSTRACT**

The influences on transmission quality caused by chirp and self-phase modulation are at least largely corrected by [~~means~~]**way** of an optimally set operating point of the modulator (2). Suitable criteria are obtained in control loops in order to maintain the optimal setting.

[~~Figure 1~~]

[~~Description~~] **SPECIFICATION**

[~~Method and arrangement for optimizing of an amplitude-modulated optical signal~~]

TITLE

METHOD AND ARRANGEMENT FOR OPTIMIZING AN AMPLITUDE-MODULATED OPTICAL SIGNAL

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The invention relates to [~~methods according to the preamble of patent claim 1, and to~~] **a method and arrangment for optimizing** an [~~arrangement according to the preamble of claim 6.~~] **amplitude-modulated optical signal.**

DESCRIPTION OF THE RELATED ART

[0002] Digital signals are frequently transmitted in optical networks with the aid of amplitude modulation (ASK). A carrier wave is transmitted in the case of one logic state, and no signal**/carrier wave** is transmitted during the other logic state. [~~As early as~~] **Early in** the modulation (on-off), [~~what is termed~~] a "chirp" is produced [~~in~~] which **changes** the wavelength **and amplitude** of the output signal [~~, and also the amplitude thereof, are changed~~]. The transient component of the chirp causes large variations in the [~~region of the edges~~] **edge regions**, **and** a sharp increase or decrease [~~, [sic]~~] in the wavelength[~~,~~]**;** the switch-on edge [~~being~~] **is** of particular importance[~~,~~] since the changes occur in the case of a full signal level. The other[~~,~~] adiabatic component of the chirp can be kept small by a suitable design of the modulator.

[0003] During transmission of [~~the~~] **a** pulse in a waveguide (glass fiber), self-phase modulation of the carrier occurs[~~,~~] **(**this being a further form of the chirp[~~,~~]**)** in which the wavelength changes likewise**,** particularly in the

leading edge region and trailing edge region of the pulse. [~~Amplitude~~]**Also, amplitude** distortions can occur[~~, in addition~~].

[0004] The two wavelength distortions, **including** the transient component of the chirp induced by switching on, and the self-phase modulation result in pulse distortion of the baseband signal[~~which~~], **contribute (**particularly in the case of transmission systems with high bit rates[~~, contribute~~]**)** to limiting the data rate and the transmission range.

[0005] An attempt is usually made to minimize the chirp-induced disturbing influences by setting operating points of Mach-Zehnder modulators or integrated electro-absorption modulators in [~~the~~]**a** test bay. However, resettings must be undertaken when changes occur to the operating parameters.

[0006] **British patent document** GB 2 308 675 A discloses an arrangement and a method for driving an optical modulator[~~. The printed publication~~] **and** describes the setting of a chirp parameter[~~. Monitoring~~] **where monitoring** the modulated signal is performed at the receiving end[~~,~~] in order to set the chirp parameters via a back channel for pulse compression.

[0007] **British patent document** GB 2 316 821 A describes an optical time-division multiplex system which compensates the chromatic dispersion of the transmission path by means of controlled chirping of the transmitted signal. Monitoring of the modulated signal is not provided.

[0008] [~~From [sic] the earlier~~]**Earlier European patent** application EP 0 971 493 A1 likewise describes a method for compensating dispersion and nonlinearities in optical communication systems. In this system, however, it is, for example, the error rate which is measured and the transmission level which is controlled as parameters. Both

measures do not appear to be expedient in modern optical systems.

SUMMARY OF THE INVENTION

[0009] It is therefore the object of the invention to [~~specify~~] **provide** a method and an [~~arrangements [sic]~~] **arrangement** for permanent optimization of the pulse shape/spectral distribution of an amplitude-modulated optical signal, particularly taking **omtp** account [~~of~~] the modulation-induced chirp and the self-phase modulation in optical transmission systems.

[0010] Achievements of this object are specified in the independent claims. Advantageous developments of the invention are specified in the subclaims.

[0011] **This object is achieved by a method for optimizing an amplitude-modulated optical signal, comprising the steps of generating the amplitude-modulated optical signal in a modulator by modulating an optical signal with a digital signal; feeding the amplitude-modulated optical signal to a frequency discriminator which outputs a spectral distribution signal; feeding the spectral distribution signal to a control device which is also fed an adjustable reference signal; and generating a control signal which sets an operating point of the modulator by comparing the adjustable reference signal and the spectral distribution signal. The inventive method may further comprise the step of separating a measuring signal which is fed to the frequency discriminator from the amplitude-modulated optical signal. The method may further comprise the steps of determining the spectral distribution signal at a start of a transmission path; and setting the reference signal based on properties of the transmission path. The method may further comprise the steps of determining the spectral distribution signal at a receiving end; and transmitting the spectral**

distribution signal or a control signal generated therefrom to the modulator provided at a transmitting end. The control signal may be obtained during periodically occurring time windows.

[0012] This object is also achieved by an arrangement for optimizing an amplitude-modulated optical signal, comprising a light source; a modulator having an output, the modulator being fed an optical signal from the light source and a digital signal for amplitude modulation; a frequency discriminator which outputs a spectral distribution signal that is connected to the output of the modulator via a splitter; and a control device with a reference signal setting device which is fed the spectral distribution signal and which generates a control signal which controls an operating point of the modulator. The arrangement may further comprise an adder which is fed the control signal and the digital signal, an adder output being fed to a modulation input of the modulator.

[0013] The measures according to the invention consist [~~in~~]**of** using quality criteria for optimal modulation of the optical signal to set the operating point of the modulator and [~~to maintain~~]**maintaining** the optimum setting by [~~means~~]**way** of a control loop.

[0014] An advantageous and simple solution is to derive a measuring signal from the modulated optical digital signal and feed it to a frequency discriminator. The output signal of the [~~latter is — [sic] led~~]**frequency discriminator is transmitted** via a control device[~~— [sic]~~] which determines the operating point of the modulator.

[0015] If the measuring signal is tapped at the receiving end, the properties of the transmission path can be taken into account [~~by means of~~]**via** an adjustable reference

signal. The output signal of the modulator is set so as to produce an optimal received signal.

[0016] If a back channel[~~,~~] **(**as a rule**,** a service channel[~~,~~]**)** is available, a measuring signal can be tapped from the baseband signal and evaluated. The spectral distribution signal output by a phase discriminator, or a control signal generated therefrom**,** will be transmitted to the source of the signal, **i.e.,** the modulator.

BRIEF DESCRIPTION OF THE DRAWING

[0017] The invention is explained in more detail with the aid of an exemplary embodiment. **The Figure is a schematic block diagram showing**~~Figure 1 shows~~ **a first exemplary embodiment with spectral appraisal.**

[~~In the drawing:~~]

[~~Figure 1 shows~~] [~~a first exemplary embodiment with spectral appraisal.~~]

DETAILED DESCRIPTION OF THE INVENTION

[0018] **The** Figure[~~1~~] shows a first exemplary embodiment of a control loop for optimizing the modulation-induced chirp. The block diagram shows only **the** modules essential to the invention. A laser provided as a narrow-band light source 1 supplies an optical signal OS of high frequency, which is fed to a modulator 2. The [~~latter~~]**optical signal** is [~~submitted~~]**subjected** to amplitude modulation by [~~means~~]**way** of a digital signal DS (on-off keying). The modulated optical signal OSM, output by the modulator, is fed into an optical conductor of a transmission path 3 and transmitted. A measuring signal OMT of low power is tapped from the modulated signal via a splitter (coupler) 4 and fed to a frequency discriminator 5. The [~~latter~~]**fequency discriminator** can include, for example, an optical filter whose edge, which is as rectilinear as possible, is used for frequency demodulation. [~~The demodulated optical signal is~~

~~converted into an electric spectral distribution signal SV and fed to a control device 6. The~~] [~~latter is fed as reference input~~] [~~an adjustable reference signal RS~~] [~~which~~] [~~is generated via a reference setting device~~] [~~7,~~] [~~a voltage divider in the example~~] [~~. The control device supplies~~] [~~as~~] [~~manipulated variable a control signal SR which sets the operating point of the modulator and thereby optimizes the transient chirp of the modulated optical signal even in the case of changes in the component properties.~~]

[0019] **The demodulated optical signal is converted into an electric spectral distribution signal SV and fed to a control device 6. The** ~~latter is fed as reference input~~**spectral distribution signal SV is fed as a reference input; an adjustable reference signal RS** ~~which~~ **is generated via a reference setting device** ~~7,~~ **7 (a voltage divider in the example). The control device supplies** ~~as~~**as a manipulated variable a control signal SR which sets the operating point of the modulator and thereby optimizes the transient chirp of the modulated optical signal even in the case of changes in the component properties.**

[0020] An optimum setting is given when the receive signal is optimal. A measurement at the receiving end is actually required for this purpose. However, a compact replacement transmission path used for the setting likewise permits an exact setting. The spectral distribution signal serves as **a** criterion during setting. A specific envelope of the modulated signal corresponds to this criterion, and can likewise serve as **a** criterion.

[0021] If the properties of the transmission path are known, they are already taken into account during setting, and the spectral distribution (or a pulse shape) is set so as to produce optimal receiving conditions.

[0022] Since the spectral distribution signal SV can be weakly dependent on the [~~on the [sic]~~]bit sequence of the digital signal, it can be expedient to have a time window ZF during which specific bit sequences are transmitted and the control signal is determined.

[0023] [~~It remains to add that the~~]**The** control signal RS and the digital signal can be combined by an adder, and the aggregate signal is then fed to the modulation input of the modulator.

[0024] As in the arrangement illustrated in [~~figure~~]**Figure** 1, it is also possible, of course, to appraise the spectral distribution of a modulated optical signal at the receiving end, and a corresponding spectral distribution signal or else the control signal derived therefrom [~~is transmitted [sic]~~]**may be provided** to the transmitting part.

[0025] **The above-described method and apparatus are illustrative of the principles of the present invention. Numerous modifications and adaptations will be readily apparent to those skilled in this art without departing from the spirit and scope of the present invention.**

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SPECIFICATION

TITLE

METHOD AND ARRANGEMENT FOR OPTIMIZING AN AMPLITUDE-MODULATED OPTICAL SIGNAL

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The invention relates to a method and arrangment for optimizing an amplitude-modulated optical signal.

DESCRIPTION OF THE RELATED ART

[0002] Digital signals are frequently transmitted in optical networks with the aid of amplitude modulation (ASK). A carrier wave is transmitted in the case of one logic state, and no signal/carrier wave is transmitted during the other logic state. Early in the modulation (on-off), a "chirp" is produced which changes the wavelength and amplitude of the output signal. The transient component of the chirp causes large variations in the edge regions, and a sharp increase or decrease in the wavelength; the switch-on edge is of particular importance since the changes occur in the case of a full signal level. The other adiabatic component of the chirp can be kept small by a suitable design of the modulator.

[0003] During transmission of a pulse in a waveguide (glass fiber), self-phase modulation of the carrier occurs (this being a further form of the chirp) in which the wavelength changes likewise, particularly in the leading edge region and trailing edge region of the pulse. Also, amplitude distortions can occur.

[0004] The two wavelength distortions, including the transient component of the chirp induced by switching on, and the self-phase modulation result in pulse distortion of the baseband signal, contribute (particularly in the case of transmission systems with high bit rates) to limiting the data rate and the transmission range.

[0005] An attempt is usually made to minimize the chirp-induced disturbing influences by setting operating points of Mach-Zehnder modulators or integrated electro-absorption modulators in a test bay. However, resettings must be undertaken when changes occur to the operating parameters.

[0006] British patent document GB 2 308 675 A discloses an arrangement and a method for driving an optical modulator and describes the setting of a chirp parameter where monitoring the modulated signal is performed at the receiving end in order to set the chirp parameters via a back channel for pulse compression.

[0007] British patent document GB 2 316 821 A describes an optical time-division multiplex system which compensates the chromatic dispersion of the transmission path by means of controlled chirping of the transmitted signal. Monitoring of the modulated signal is not provided.

[0008] Earlier European patent application EP 0 971 493 A1 likewise describes a method for compensating dispersion and nonlinearities in optical communication systems. In this system, however, it is, for example, the error rate which is measured and the transmission level which is controlled as parameters. Both measures do not appear to be expedient in modern optical systems.

SUMMARY OF THE INVENTION

[0009] It is therefore the object of the invention to provide a method and an arrangement for permanent optimization of the pulse shape/spectral distribution of an amplitude-modulated optical signal, particularly taking omtp account the modulation-induced chirp and the self-phase modulation in optical transmission systems.

[0010] Achievements of this object are specified in the independent claims. Advantageous developments of the invention are specified in the subclaims.

[0011] This object is achieved by a method for optimizing an amplitude-modulated optical signal, comprising the steps of generating the amplitude-modulated optical signal in a modulator by modulating an optical signal with a digital signal; feeding the amplitude-modulated optical signal to a frequency discriminator which outputs a spectral distribution signal; feeding the spectral distribution signal to a control device which is also fed an adjustable reference signal; and generating a control signal which sets an operating point of the modulator by comparing the adjustable reference signal and the spectral distribution signal. The inventive method may further comprise the step of separating a measuring signal which is fed to the frequency discriminator from the amplitude-modulated optical signal. The method may further comprise the steps of determining the spectral distribution signal at a start of a transmission path; and setting the reference signal based on properties of the transmission path. The method may further comprise the steps of determining the spectral distribution signal at a receiving end; and transmitting the spectral distribution signal or a control signal generated therefrom to the modulator provided at a transmitting end. The control signal may be obtained during periodically occurring time windows.

[0012] This object is also achieved by an arrangement for optimizing an amplitude-modulated optical signal, comprising a light source; a modulator having an output, the modulator being fed an optical signal from the light source and a digital signal for amplitude modulation; a frequency discriminator which outputs a spectral distribution signal that is connected to the output of the modulator via a splitter; and a control device with a reference signal setting device which is fed the spectral distribution signal and which generates a control signal which controls an operating point of the modulator. The arrangement may further comprise an adder which is fed the control signal

and the digital signal, an adder output being fed to a modulation input of the modulator.

[0013] The measures according to the invention consist of using quality criteria for optimal modulation of the optical signal to set the operating point of the modulator and maintaining the optimum setting by way of a control loop.

[0014] An advantageous and simple solution is to derive a measuring signal from the modulated optical digital signal and feed it to a frequency discriminator. The output signal of the frequency discriminator is transmitted via a control device which determines the operating point of the modulator.

[0015] If the measuring signal is tapped at the receiving end, the properties of the transmission path can be taken into account via an adjustable reference signal. The output signal of the modulator is set so as to produce an optimal received signal.

[0016] If a back channel (as a rule, a service channel) is available, a measuring signal can be tapped from the baseband signal and evaluated. The spectral distribution signal output by a phase discriminator, or a control signal generated therefrom, will be transmitted to the source of the signal, i.e., the modulator.

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[0017] The invention is explained in more detail with the aid of an exemplary embodiment. The Figure is a schematic block diagram showing a first exemplary embodiment with spectral appraisal.

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[0018] The Figure shows a first exemplary embodiment of a control loop for optimizing the modulation-induced chirp. The block diagram shows only the modules essential to the invention. A laser provided as a narrow-band light source 1 supplies an optical signal OS of high frequency, which is

fed to a modulator 2. The optical signal is subjected to amplitude modulation by way of a digital signal DS (on-off keying). The modulated optical signal OSM, output by the modulator, is fed into an optical conductor of a transmission path 3 and transmitted. A measuring signal OMT of low power is tapped from the modulated signal via a splitter (coupler) 4 and fed to a frequency discriminator 5. The fequency discriminator can include, for example, an optical filter whose edge, which is as rectilinear as possible, is used for frequency demodulation.

[0019] The demodulated optical signal is converted into an electric spectral distribution signal SV and fed to a control device 6. The spectral distribution signal SV is fed as a reference input; an adjustable reference signal RS is generated via a reference setting device 7 (a voltage divider in the example). The control device supplies as a manipulated variable a control signal SR which sets the operating point of the modulator and thereby optimizes the transient chirp of the modulated optical signal even in the case of changes in the component properties.

[0020] An optimum setting is given when the receive signal is optimal. A measurement at the receiving end is actually required for this purpose. However, a compact replacement transmission path used for the setting likewise permits an exact setting. The spectral distribution signal serves as a criterion during setting. A specific envelope of the modulated signal corresponds to this criterion, and can likewise serve as a criterion.

[0021] If the properties of the transmission path are known, they are already taken into account during setting, and the spectral distribution (or a pulse shape) is set so as to produce optimal receiving conditions.

[0022] Since the spectral distribution signal SV can be weakly dependent on the bit sequence of the digital signal, it can be expedient to have a time window ZF during which

specific bit sequences are transmitted and the control signal is determined.

[0023] The control signal RS and the digital signal can be combined by an adder, and the aggregate signal is then fed to the modulation input of the modulator.

[0024] As in the arrangement illustrated in Figure 1, it is also possible, of course, to appraise the spectral distribution of a modulated optical signal at the receiving end, and a corresponding spectral distribution signal or else the control signal derived therefrom may be provided to the transmitting part.

[0025] The above-described method and apparatus are illustrative of the principles of the present invention. Numerous modifications and adaptations will be readily apparent to those skilled in this art without departing from the spirit and scope of the present invention.

LIST OF REFERENCE SYMBOLS

DS	Digital signal
DD	Demodulated digital signal
1	Laser
2	Modulator
3	Optical conductor
4	Splitter
5	Discriminator
6	Control device
7	Reference setting device
RS	Reference signal
OS	Optical signal
OSM	Amplitude-modulated optical signal
OMT	Measuring signal
SV	Spectral distribution signal
SF	Control signal
ZF	Time window
8	Summing device
9	Receiving device
10	Optoelectric transducer
11	Amplifier
12	Decision circuit
13	Data output
14	Measuring instrument appraising device
15	Evaluation device
16	Controller
17	Modulation input
18	Transmitting device
19	Receiving device
SE	Setting signal

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18	Transmitting device
19	Receiving device
SE	Setting signal

ABSTRACT

The influences on transmission quality caused by chirp and self-phase modulation are at least largely corrected by way of an optimally set operating point of the modulator (2). Suitable criteria are obtained in control loops in order to maintain the optimal setting.

FIG 1

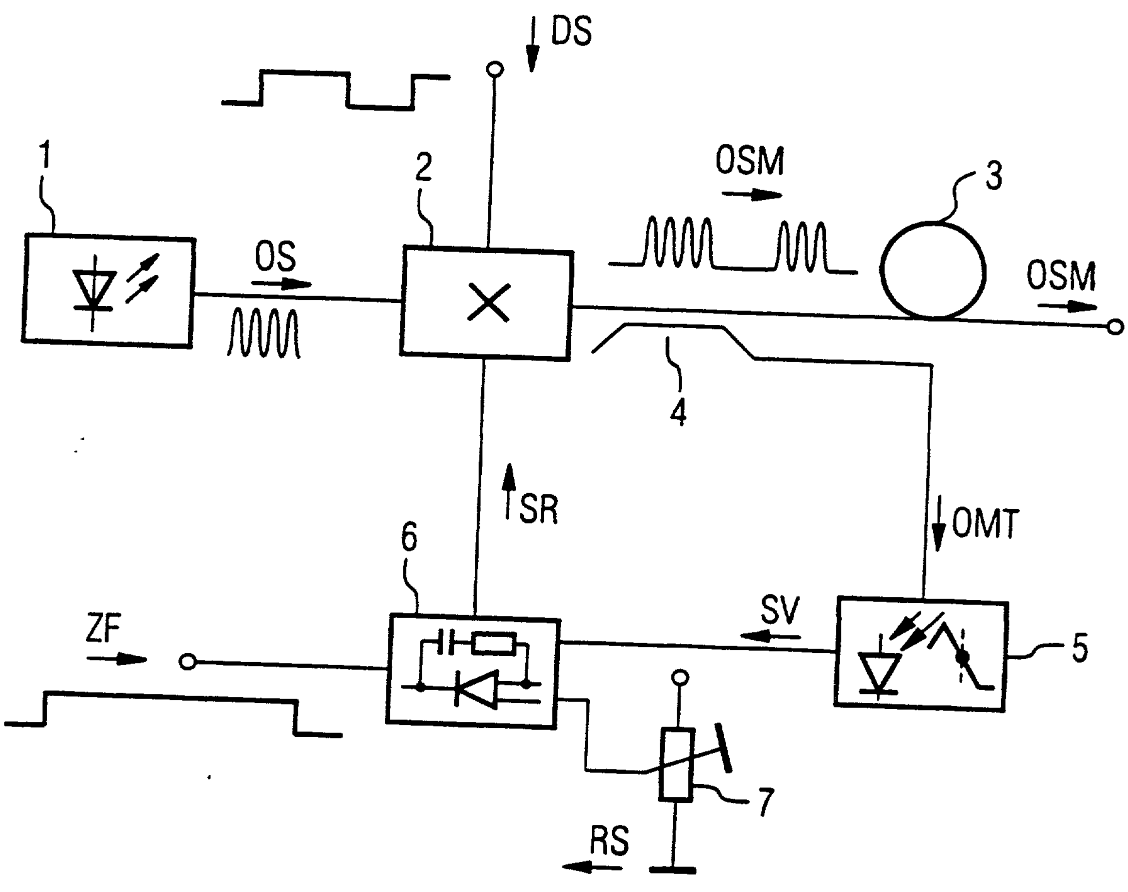
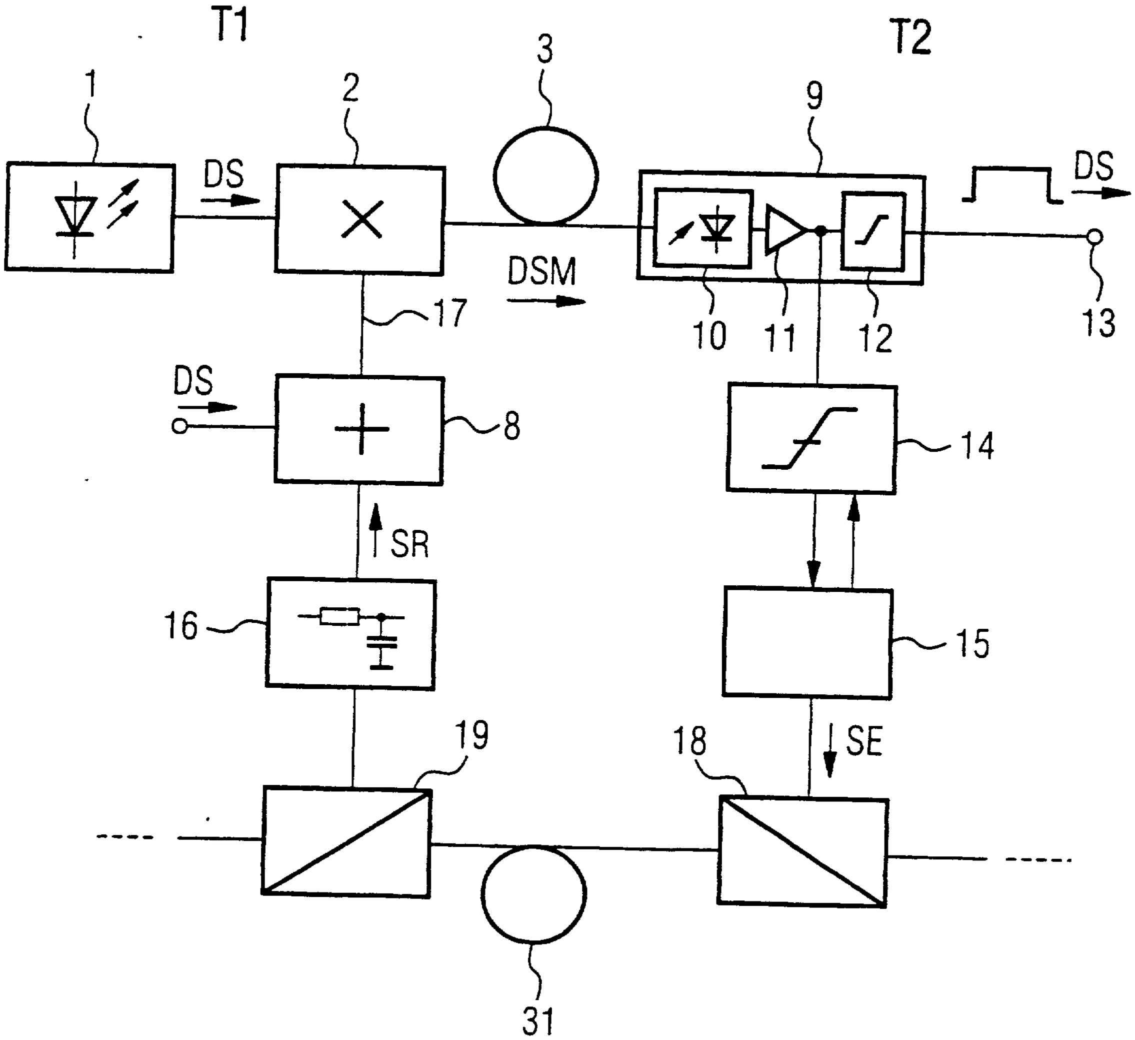


FIG 2



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Erklärung Für Patentanmeldungen Mit Vollmacht

German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:

As a below named inventor, I hereby declare that:

dass mein Wohnsitz, meine Postanschrift, und meine Staatsangehörigkeit den im Nachstehenden nach meinem Namen aufgeführten Angaben entsprechen,

My residence, post office address and citizenship are as stated below next to my name,

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I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Verfahren und Anordnung zur Optimierung der Impulsform eines amplitudenmodulierten optischen Signals

deren Beschreibung

the specification of which

(zutreffendes ankreuzen)

☒ hier beigefügt ist.

☐ am ____________ als PCT internationale Anmeldung
PCT Anmeldungsnummer ____________
Eingereicht wurde und am ____________
Abgeändert wurde (falls tatsächlich abgeändert).

(check one)

☐ is attached hereto.

☐ was filed on ____________ as PCT international application
PCT Application No. ____________
and was amended on ____________ (if applicable)

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I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

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I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

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Prior foreign appplications
Prioritát beansprucht

Priority Claimed

(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	Yes Ja	No Nein
19908813.6	Germany	01. März 1999	☒	☐
			☐	☐
			☐	☐

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(Application Serial No.) (Anmeldeseriennummer)	(Filing Date) (Anmeldedatum)	(Status) (patentiert, anhängig, aufgegeben)	(Status) (patented, pending, abandoned)

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POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

And I hereby appoint

Messrs. John D. Simpson (Registration No. 19,842) Lewis T. Steadman (17,074), William C. Stueber (16,453), P. Phillips Connor (19,259), Dennis A. Gross (24,410), Marvin Moody (16,549), Steven H. Noll (28,982), Brett A. Valiquet (27,841), Thomas I. Ross (29,275), Kevin W. Guynn (29,927), Edward A. Lehmann (22,312), James D. Hobart (24,149), Robert M. Barrett (30,142), James Van Santen (16,584), J. Arthur Gross (13,615), Richard J. Schwarz (13,472) and Melvin A. Robinson (31,870), David R. Metzger (32,919), John R. Garrett (27,888) all members of the firm of Hill, Steadman & Simpson, A Professional Corporation.

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Staatsangehörigkeit Bundesrepublik Deutschland DEX	Citizenship
Postanschrift Menterschwaigstr. 14	Post Office Address
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(Bitte entsprechende Informationen und Unterschriften im Falle von dritten und weiteren Miterfindern angeben).

(Supply similar information and signature for third and subsequent joint inventors).